Safety analysis of infrared toy gun based on EN 62471 standards

A., Calibration of detector

1. Goal of measurement:

We need to calibrate our Coherent Lasermate measurement device equipped with Q VIS sensor, since the speed of our calibrated Fieldmax II instrument equipped with Powermax PS19 sensor is not enough for analyzing the 36kHz signal of the gun.

2. Tools used:

Coherent Lasermate with Q VIS sensor,

Coherent Fieldmax II. instrument with Powermax PS 19 sensor,

Vishay TSAL6200 LED,

Agilent E3631A power supply

3. Progress of measurement

The LED was driven by the power supply at about 20mA constant forward current. The LED is contacted to the surface of detectors, so the total power is measured with good approximation.

Power measured with Fieldmax II.:	9.7mW
Power measured with Coherent Lasermate Q (Set wavelength: 534nm, Range: 100mW):	4.2mW
Multiplier:	9.7mW/4.2mW=2.31

Values measured by Coherent Lasermate Q have to be multiplied by the factor of 2.31 to get the correct power value.

B., Measuring pulse power

1. Goal of measurement:

Determining the pulse power according to the specifications of the standard.

2. Tools used:

Gun number „7",

Coherent Lasermate with Q VIS sensor,

HP 54615B oscilloscope.

3. Progress of measurement

According to the standard, a source with α=0.0017rad angular size must be measured for shorter periods than 0.25s (page 27), for longer radiations the angular size must be calculated by $\alpha_{eff}=\alpha_{min}(t/0.25)^{0.5}$ equation .

In case of devices emitting low intensity visible light, it is necessary to use a 7mm diameter measuring aperture.

Measurements have to be performed at a distance of 200mm away from the emitting source. (page 59)

As an upper approximation we measure with an aperture of 8mm (sensor diameter of Coherent LaserMate Q) at a distance of 10mm in case of the main shot tube, and at a 200mm distance in case of the secondary shot tube.

Also as an upper approximation we do not apply an aperture on the light source according to the standard (page 51, figure 5.3) when we calculate radiance, and we measure total power.

We connect the Coherent Lasermate Q instrument to the oscilloscope. At the instrument output there is 100mV voltage at 100mW range and 10mW displayed power.

Measurement results:

Main shot tube:

Maximum:	62mV
Measured pulse power:	6.2mW
Corrected by multiplier:	14.3mW

Secondary shot tube:

Maximum:	24mV
Measured pulse power:	2.4mW
Corrected by multiplier:	5.6mW

C. Safety limits according to the standard

Main shot tube

I., Retinal thermal hazard exposure limit

We measure with a >7mm detector at a distance of 10mm from the gun, but we calculate as if the total power would come from a 0.0017rad cone. (highly overestimated)

1., For one pulse			2., For one 73ms long pulse sequence (average)		
Meas. power	14.3	mW	Meas. power	14.3	mW
Time	0.0000278	s	Time	0.073	s
Src. angle	0.0017	rad	Src. angle	0.0017	rad
Solid angle	9.0792E-06	str	Solid angle	9.0792E-06	str
Det. area	0.5	cm2	Det. area	0.5	cm2
L_λ	31500563.13	W/m2/str	L_λ	31500563.13	W/m2/str
λ	950	nm	λ	950	nm
$R(\lambda)$	0.316227766		$R(\lambda)$	0.316227766	
α	0.0017		α	0.0017	
L_R	9.96E+06	W/m2/str	L_R	4.98E+06	W/m2/str
Limit	4.05E+08	W/m2/str	Limit	5.66E+07	W/m2/str
3., within 1s			4., within 10s		
Meas. power	14.3	mW	Meas. power	14.3	mW
Time	1	s	Time	10	s
Src. angle	0.0034	rad	Src. angle	0.010751744	rad
Solid angle	3.63168E-05	str	Solid angle	0.000363168	str
Det. area	0.5	cm2	Det. area	0.5	cm2
L_λ	7875140.783	W/m2/str	L_λ	787514.0783	W/m2/str
λ	950	nm	λ	950	nm
$R(\lambda)$	0.316227766		$R(\lambda)$	0.316227766	
α	0.0017		α	0.0017	
L_R	2.73E+05	W/m2/str	L_R	2.73E+04	W/m2/str
Limit	2.94E+07	W/m2/str	Limit	1.65E+07	W/m2/str

I.B., Retinal thermal hazard exposure limit - weak visual stimulus

We measure with a >7mm detector at a distance of 10mm from the gun, but we calculate as if the total power would come from a 0.0017rad cone. (highly overestimated)

1., within 10s		
Meas. power	14.3	mW
Time	10	s
Src. angle	0.010751744	rad
Solid angle	0.000363168	str
Det. area	0.5	cm2
L_λ	787514.0783	W/m2/str
λ	950	nm
$R(\lambda)$	0.316227766	
α	0.0017	
L_R	2.73E+04	W/m2/str
Limit	1.65E+07	W/m2/str

II., Infrared radiation hazard exposure limit for the eye

We measure with a >7mm detector at a distance of 10mm from the gun

1., For one pulse			2., For one 73ms long pulse sequence (average)		
Meas. power	14.3	mW	Meas. power	14.3	mW
Time	0.0000278	s	Time	0.073	s
Det. area	0.5	cm2	Det. area	0.5	cm2
L_λ	286	W/m2	L_λ	286	W/m2
L_R	2.86E+02	W/m2	L_R	1.43E+02	W/m2
Limit	4.70E+07	W/m2	Limit	1.28E+05	W/m2
3., within 1s			4., within 1000s		
Meas. power	14.3	mW	Meas. power	14.3	mW
Time	1	s	Time	1000	s
Det. area	0.5	cm2	Det. area	0.5	cm2
L_λ	286	W/m2	L_λ	286	W/m2
L_R	3.13E+01	W/m2	L_R	3.13E+01	W/m2
Limit	1.80E+04	W/m2	Limit	1.01E+02	W/m2

Secondary shot tube

I., Retinal thermal hazard exposure limit

We measure with a >7mm detector at a distance of 10mm from the gun, but we calculate as if the total power would come from a 0.0017rad cone. (highly overestimated)

1., For one pulse			2., For one 73ms long pulse sequence (average)		
Meas. power	5.6	mW	Meas. power	5.6	mW
Time	0.0000278	s	Time	0.073	s
Src. angle	0.0017	rad	Src. angle	0.0017	rad
Solid angle	9.0792E-06	str	Solid angle	9.0792E-06	str
Det. area	0.5	cm2	Det. area	0.5	cm2
L_λ	12335884.86	W/m2/str	L_λ	12335884.86	W/m2/str
λ	950	nm	λ	950	nm
$R(\lambda)$	0.316227766		$R(\lambda)$	0.316227766	
α	0.0017		α	0.0017	
L_R	3.90E+06	W/m2/str	L_R	1.95E+06	W/m2/str
Limit	4.05E+08	W/m2/str	Limit	5.66E+07	W/m2/str

3., within 1s			4.,within 10s		
Meas. power	5.6	mW	Meas. power	5.6	mW
Time	1	s	Time	1	s
Src. angle	0.0034	rad	Src. angle	0.0034	rad
Solid angle	3.63168E-05	str	Solid angle	3.63168E-05	str
Det. area	0.5	cm2	Det. area	0.5	cm2
L_λ	3083971.216	W/m2/str	L_λ	3083971.216	W/m2/str
λ	950	nm	λ	950	nm
$R(\lambda)$	0.316227766		$R(\lambda)$	0.316227766	
α	0.0017		α	0.0017	
L_R	1.07E+05	W/m2/str	L_R	1.07E+05	W/m2/str
Limit	2.94E+07	W/m2/str	Limit	2.94E+07	W/m2/str

I.B., Retinal thermal hazard exposure limit - weak visual stimulus

We measure with a >7mm detector at a distance of 10mm from the gun, but we calculate as if the total power would come from a 0.0017rad cone. (highly overestimated)

1., within 10s

Meas. power	5.6	mW
Time	10	s
Src. angle	0.010751744	rad
Solid angle	0.000363168	str
Det. area	0.5	cm2
L_λ	308397.1216	W/m2/str
λ	950	nm
$R(\lambda)$	0.316227766	
α	0.0017	
L_R	1.07E+04	W/m2/str
Limit	1.65E+07	W/m2/str

II., Infrared radiation hazard exposure limit for the eye

We measure with a >7mm detector at a distance of 10mm from the gun

1., For one pulse			2., For one 73ms long pulse sequence (average)		
Meas. power	5.6	mW	Meas. power	5.6	mW
Time	0.0000278	s	Time	0.073	s
Det. area	0.5	cm2	Det. area	0.5	cm2
L_λ	112	W/m2	L_λ	112	W/m2
L_R	1.12E+02	W/m2	L_R	1.12E+02	W/m2
Limit	4.70E+07	W/m2	Limit	1.28E+05	W/m2
3., 1s alatt			4., 1000s alatt		
Meas. power	5.6	mW	Meas. power	5.6	mW
Time	1	s	Time	1000	s
Det. area	0.5	cm2	Det. area	0.5	cm2
L_λ	112	W/m2	L_λ	112	W/m2
L_R	1.23E+01	W/m2	L_R	1.23E+01	W/m2
Limit	1.80E+04	W/m2	Limit	1.01E+02	W/m2

D., Results:

It can be clearly seen, that the gun is in the so called "Exempt" category (page 59.), it does not cause any harm on human body according to the standard.

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